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*Full Length Research*

# CO-INTEGRATION AND VECTOR ERROR CORRECTION MODELS ANALYSIS OF PRODUCER PRICES OF CASSAVA, RICE AND MAIZE

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**This study analyzed the relationship among producer prices of cassava, rice and maize in Nigeria. The study used annual time series data spanning from 1991 to 2013. Results from Augmented Dickey Fuller test showed that the time series data were not stationary in their level forms but were integrated of order one, 1. The trace test and maximum Eigen values of Johansen co-integration test indicated 3 co-integrations at the 5 percent level which showed there is a long run relationship among the variables during the period of study. The result of the VECM showed the Maize producer price responded faster than the Cassava and Rice prices. The adjustment coefficient was not statistically significant for the three selected producer prices suggesting that the Cassava and Rice prices are strongly exogenous. This implies that movement in Cassava and Rice prices was highly affected by price in Maize while movement in price of Maize was dictated by events in cassava and rice prices. This means that the long run equilibrium in the producer prices after exogenous shock is restored primarily by corrections made by producer prices of maize. Granger causality showed that cassava producer price determined the producer prices of rice and maize which indicated a unidirectional causality. Producer prices of rice and maize neither granger caused each other. Hence, the null hypothesis that the producer price does not granger cause each other is rejected. Therefore, price policy in favour of cassava cultivation should be promoted.**

**Key Words:** Co-integration, VECM, Granger Causality, Producer Price, Maize, Cassava, Rice.

## INTRODUCTION

Agricultural sector is an important sector of Nigerian economy that has contributed to the Gross Domestic Product of the country from time immemorial. Though its contributions had been dropping relative to the GDP (Abdul Rasheed, 2010), the sector contributed about 31.9% to the GDP in 2014 (Worldometer, 2015). Despite this contribution the crop subsector has failed in meeting the food demand of Nigeria populace which is estimated at 167 million (NBS, 2012) leading to high rate of food importation even though it has been established that food demand is higher than food production in Nigeria (Idrisa et al., 2008). This failure is attributed to several factors such as lack of inputs, use of crude implements, rural-urban migration, low technology adoption,

catastrophes among others (Shimada, 1999).

## CEREALS

Cereals are the world's most important source of food directly for human and indirectly as input for livestock feeds. Cereal crops include rice, wheat, maize, millet, sorghum, rye, durum among others. The world's production of these crops is projected as 2540 millon tonnes in 2015 and their utilization is projected as 2536 million tonnes for the same year (FAO, 2015). Nigeria production was put at 24.66 million metric tonnes in 2010 which later rose to 26.97 million metric tonnes in 2013 (World Bank, 2013).Though, the productivity of crops increases yearly but at a very low percentage and the increase in productivity of these crops is important so as to meet food demand, reduce food importation, lower food prices, combat malnutrition and poverty. This is evident from the fact that growth from agriculture especially in the crop subsector is at least twice as effective in reducing poverty as growth from other sectors (Irz et al., 2001).

## CASSAVA

Cassava (*Manihot esculenta*) is one of the principal root and tuber crops of the tropics widely grown and consumed as subsistence staple (FAO, 2017b). According to Nteranya and Adiel (2015), some of the compelling reasons for encouraging the cultivation of root and tuber crops for sustainable food production in Africa are:

(i) They are versatile staples capable of addressing food and nutrition security and produce more food per unit area of land, compared to many other crops;

(ii) Though longer in their cropping cycle, are vital in annual cycle of food availability due to their broader agro ecological adaptation, diverse maturity period and in ground storage capacity, permitting flexibility kin harvesting period for sustained food availability and

(iii) They are far less susceptible to large scale market shocks and price speculations experienced by more widely traded staples, such as grains. It is highly productive, it is available throughout the year, and can be processed into many floods, depending on local customs and preference (IITA, 2005). Cassava production has been increasing for the past 20 years in area cultivated and in yield per hectare (Amans et al., 2004). Nigeria was the world largest producer of cassava in the world with an estimated output of 54 million metric tons in 2013, accounting for 21% of the global total (Olaniyan, 2015). Cassava is also a major cash crop that generates income for a large number of households. It is produced in Nigeria largely by small-scale farmers using simple farm implement such as cutlass and hoe.

Producer prices are prices received by farmers for primary crops, live animals and livestock products as collected at the point of initial sale, that is, prices paid at the farm gate (FAO, 2017b). Producer prices are usually an inducement for farmers to produce (Enete and Amusa, 2010). According to Ndhlovu and Seshamani (2016), farmers are more likely to consider past experiences and make the best guess of the prices. Producer prices may impact on the area and yield of cassava. Given the role cassava play as a major source of staples, availability of cassava products may be affected by producer prices directly or indirectly through its impacts on area harvested and yield.

## METHODOLOGY

### Data and Analytical Procedure

Annual time series data on producer prices of cassava, rice and maize spanning from 1991 to 2013 were collected from FAOSTAT (2017a). Producer Prices were measured in naira per tonne. Given that the study used time series data, a preliminary analysis of the unit root test of producer prices using Augmented Dickey Fuller (ADF) test was carried out to avoid a spurious regression. In order to examine the long –run relationship among cassava, rice and maize producer prices, the Johansen's Maximum likelihood (1991, 1995) co-integration technique was employed.

The casual relationship among the producer prices was anlysed using Granger casuality test (Granger, 1969) and the short run relationship through Vector Error Correction Model (VECM).

The first step is to examine the stationary properties of the various prices using ADF test. If a series, say $P_{t,}$ is stationary, invertible and stochastic after differencing d times, it is said to be integrated of order d, and denoted by $P_t$ = I(d). The statistical tests to determine whether the economic variables were I (0) or I (1) using the Johansen test. Alufohai

and Ayantoyinbo (2014) formulation test on residual from the co-integration regression is as follows:

$P_t = \alpha+\beta_1 P_{t2}+\beta_2 Pt_3+e_t$ …………………………….. (1)

Where;

t= time

$e_t$ = residual error term assumed to be distributed identically and independently.

$P_{1t}$, $P_{2t}$, $P_{3t}$= Producer prices series of Cassava, Rice and Maize

The null hypothesis of non-stationary cannot be rejected, when the absolute value of the ADF statistic is smaller than the critical ADF values, and the next stage will be to test whether the first differences are stationary. If the null hypothesis of non-stationary cannot be rejected, then the series is still not stationary. Therefore, differencing continues until the series becomes stationary and order noted. The process is considered stationary if /δ/<1, thus testing for stationary is equivalent with testing for unit roots (δ<1) under the following hypothesis:

Ho: δ = 0 the price series is non-stationary or there is unit root.

H1: δ ≠0 the price series is stationary or there is no unit root i.e. there is white noise in the series.

The hypothesis of non-stationary will be accepted at 0.01 or 0.05 levels if ADF is greater than the critical value. The residual from the above equation are considered to be temporary deviation from the long run equilibrium.

$\Delta e_t = \gamma e_{t-1} + \Sigma_{i=1}^{p} \, yi\Delta_{et-1} + \sigma_t$ ……………………..(2)

(Mussema, 2006)

Consider a pair of variables $Pt^1$ and $Pt^2$ each of which is integrated of order d their linear relationship can be given by:

$e_{t-1} = P_{1t-1} - \alpha - P_{2t-1}$ … … … . … … … … … … … … (3)

(Fayaz and Naresh 2014)

In order to conclude that the prices series are co-integrated the residuals from the equation have to follow stationarity. If the residual errors are stationary then the linear combination of the two prices is stationary (co integrated). If the t-statistic of the coefficient does not exceed the critical value the residuals, $e_{t-1}$ from the co-integration equation are stationary (Engle and Yoo, 1987), and thus the price series $P^{1t}$ and $P^{2t}$ are co-integrated. When co-integrated between times series is evident there is an identification of a single market.

**Granger Causality Test:** The test is used to test existence and the direction of long-run causal price relationship between the markets (Granger, 1969). The Granger Causality test was used to determine the leading price among the three crop prices.

Granger causality provides additional evidence as to whether, and in which direction, price integration and transmission is occurring between three prices series or market levels. The test was based on the following pairs of OLS regression equations through a bivariate VAR:

$CP_t = \alpha 0 + \Sigma_{i=1}^{m} \alpha_i RP_{t=i} + \Sigma_{i=1}^{n} \beta j CP_t = j + \epsilon_t$ … … … … … … … … . (4)

$RP_t = \alpha_0 + \Sigma_{i=1}^{m} \alpha_i MP_t = i + \Sigma_{i=1}^{n} \beta j RP_t = j + \epsilon_t$ … … … … … … … … . (5)

$MP_t = \alpha_0 + \Sigma_{i=1}^{m} \alpha_i CP_t = i + \Sigma_{i=1}^{n} \beta j RP_t = j + \epsilon_t$ … … … … … … … … (6)

Where;

$\mathrm{n} = \text{number of observations}$

$\mathrm{m} = \text{number of lag}$

$CP_t = \text{Cassava Price}$

$MP_t = \text{Maize Price}$

$RP_t = \text{Rice Price}$

α and β = parameters to be estimated

## ERROR CORRECTION MODEL (ECM)

The ECM was applied to investigate further on short run interaction causality between variables and ability to correct long run deviation in the short run.

$\Delta p_{1t} = \alpha\Sigma\beta_1\Delta p_{1t-k} + \delta\Delta\hat{e}_{t-1} + \Sigma\beta_2\Delta p_{2t-k} + \beta_3\Delta p_{2t} + \varepsilon_t$…………(8)

Where;

$\beta_1$, $\beta_2$, $\beta_3$ = the estimated short run counterparts to the long run solution.

k= the lag length of the time,

δ=the speed of adjustment parameter, which indicates how fast the previous moves back towards long run equilibrium in case of deviation in the previous time period.

$\varepsilon_t$ =is the stationary random process capturing other information not contained in either lagged value of $p_{1t}$ and $p_{2t}$

$\hat{e}_{t-1}$ = error correction term, obtained from the co-integration equation captures the deviation from long –run equilibrium.

## RESULTS AND DISCUSSIONS

### Testing for Stationarity: Unit Root Test Results

In order to ascertain whether the variables were stationary or not, ADF unit root test was applied at ground levels and first differences of the price series. The results are presented in Table 1. The empirical evidence suggests that price series were not stationary in their level form and any attempt to use the non-stationary variables could lead to spurious regression results and such results cannot

**Table 1.** ADF Unit Root Test Results in Levels and First Differences.

| Producer Prices | At level/First difference | ADF Test | P values | Remarks |
|---|---|---|---|---|
| Cassava | I (0) | -1.579905 | 0.4739 | Non-stationary |
| | I(1) | -7.507380 | 0.0000 | Stationary |
| Rice | I(0) | -1.440596 | 0.5419 | Non-stationary |
| | I(1) | -7.531882 | 0.0000 | Stationary |
| Maize | I(0) | -1.306434 | 0.6043 | Non-stationary |
| | I(1) | -5.760425 | 0.0002 | Stationary |

I(0) – Price level and I(1)- first differences
**Source:** Author's Computation using E-views software computed from Secondary Data, 2017.

be used for prediction in the long run.

The null hypothesis which states that producer prices of one crop do not determine prices of another cannot be rejected at $P<0.05$.

When first-differenced, however, the null hypothesis of non-stationarity was rejected in favour of alternative as the values of the ADF t-statistic were greater in absolute term than the critical value. This result is necessary and sufficient for a test of co-integration of the price series.

## Co integration Test Results

Both Trace and Maximum Eigen value statistics indicate the existence of co-integration relationship at 5 percent significant level for the three crops. To check the null hypothesis that the variables were not co-integrated (r=0), trace and eigen-value statistics were calculated; results showed that the maximum eigen-value and trace statistics values were higher than 5 percent critical values. Therefore, the null hypothesis was rejected and the alternative accepted for one or more co-integrating vectors.

Similarly, the null hypothesis; r=0, and $r \leq 1$ both statistics were rejected against their alternative hypothesis of $r \geq 1$

The null hypothesis $r \geq 2$ from both tests (trace test and maximum eigen-value test) were accepted and their alternative hypotheses (r=3) were rejected as the trace value and maximum eigen-value well below their corresponding critical values at 5% of significance. Both tests confirmed that all three selected crops had 3 co –integrating equations, indicating that they were well integrated and price signals were transferred from one crop to another to ensure efficiency. Thus, Johansen co-integration test has shown that though the selected crops in Nigeria were geographically remote areas and spatially segmented, they were well connected in terms of prices of the crops, demonstrating that the selected crops during study period were co-integrated and had long run price linkage across them. Thus, the cassava, rice and maize producer prices were co-integrated and there existed long run equilibrium. This was supported by earlier studies carried out by Mesike (2012) who concluded that cocoa and rubber market price within Nigeria are highly integrated; and the findings of Emokaro and Ayantoyinbo (2014) the result indicates that the rice markets in Osun State were co-integrated and there existed long run equilibrium.

## Long run Relationship among Producer Prices of Cassava, Rice and Maize

The long run relationship among producer prices of cassava, rice and maize was examined using the Johansen co-integration test. Results from both the trace and maximum Eigen values are presented in Table 2. The trace test and maximum Eigen values indicate 3 co-integrations at the 5 percent level. Consequently, the null hypothesis that there is no long run relationship between the producer prices of cassava, rice and maize can be rejected and alternative hypothesis accepted. Hence, this implies that there is long–run relationship among the producer prices of cassava, rice and maize. This on the other hand indicates that the variables do move jointly over time. The existence of long run relationship also implies that if these variables move away from the mean or equilibrium level, it will be easy to bring them back to equilibrium since there is

**Table 2.** Unrestricted Co-integration Rank Test (Trace).

| **Hypothesized** No. of CE(s) | **Eigenvalue** | **Trace Statistic** | **0.05 Critical Value** | **Prob.**** |
|---|---|---|---|---|
| None * | 0.796400 | 50.78503 | 29.79707 | 0.0001 |
| At most 1 * | 0.515176 | 18.95303 | 15.49471 | 0.0144 |
| At most 2 * | 0.200430 | 4.473624 | 3.841466 | 0.0344 |

Trace test indicates 3 co-integrating eqn (s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

***MacKinnon-Haug-Michelis (1999) p-values

**Unrestricted Co-integration Rank Test (Maximum Eigenvalue)**

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.796400 | 31.83200 | 21.13162 | 0.0011 |
| At most 1 * | 0.515176 | 14.47941 | 14.26460 | 0.0462 |
| At most 2 * | 0.200430 | 4.473624 | 3.841466 | 0.0344 |

Max-eigenvalue test indicates 3 co-integrating eqn (s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level
***MacKinnon-Haug-Michelis (1999) p-values
**Source:** Author's Computation using E-views software computed from Secondary Data, 2017.

**Table 3.** Short-run Analysis using VECM.

| **Error Correction:** | **D(CASPPT)** | **D(RICEPPT)** | **D(MAIZET)** |
|---|---|---|---|
| CointEq1 | 1.429975 | 0.850086 | 2.779211 |
| | (0.39067) | (1.16419) | (1.24322) |
| | [ 3.66030] | [ 0.73020] | [ 2.23549] |

**Source:** Author's Computation using E-views software computed from Secondary Data, 2017 Note: All figures in brackets (…) are standard errors and all figures in parenthesis […] are t-values

error correction link among them.

**Short Run Co-integration Relationship**

The VECM was employed in order to analyse the short run dynamics of the effects of producer prices of the three selected crops, having established that a long run relationship existed among the variables.

The result of the VECM in Table 3 show that if there is a positive deviation from the long run equilibrium the crop price tends to respond with a decrease or increase in the other crop price. The Maize producer price appears to respond faster than the Cassava and Rice prices. The adjustment coefficient was not statistically significant for the three selected producer prices suggesting that the Cassava and

**Table 4.** GRANGER CAUSALITY TESTS.

| Pairwise Granger Causality Tests | | | |
|---|---|---|---|
| Date: 11/07/17 Time: 11:22 | | | |
| Sample: 1991 2013 | | | |
| Lags: 2 | | | |
| **Null Hypothesis:** | **Obs** | **F-Statistic** | **Prob.** |
| MAIZEPPT does not Granger Cause CASSAVAPPT | 20 | 0.88703 | 0.4324 |
| CASSAVAPPT does not Granger Cause MAIZEPPT | | 3.71040 | 0.0491 |
| | | | |
| RICE__PADDYPPT does not Granger Cause CASSAVAPPT | 20 | 0.62104 | 0.5506 |
| CASSAVAPPT does not Granger Cause RICE__PADDYPPT | | 6.94894 | 0.0073 |
| | | | |
| RICE__PADDYPPT does not Granger Cause MAIZEPPT | 20 | 0.67231 | 0.5253 |
| MAIZEPPT does not Granger Cause RICE__PADDYPPT | | 0.19361 | 0.8260 |

Rice prices are strongly exogenous. This implies that movement in Cassava and Rice prices was highly affected by price in Maize while movement in price of Maize was dictated by events in cassava and rice prices. This means that the long run equilibrium in the producer prices after exogenous shock is restored primarily by corrections made by producer prices of maize.

The coefficient of the error correction term, which signifies the speed at which producer prices in the three selected crops adjust to their long run equilibrium level, was positive but statistically not significant. The coefficient of the error correction term of 2.779211 implies that, the feedback into the short-run dynamics process from the previous period is 277.92% and the positive sign suggests that the adjustment is from a higher price shock (price rise) to the long run price level. This means that the adjustment from the short-run to long –run equilibrium was about 277.92% which is relatively strong compared with the perfect adjustment of 100% threshold. It suggests that the prices of cassava, rice and maize adjust strongly to its long-run level after a price rise (shock). The error correction term has important feature for determining the time period after any deviation from long run equilibrium (Fayaz and Naresh, 2014).

## GRANGER CAUSALITY TESTS

The F-statistic for the causality tests of prices of the chosen commodities is statistically significant. The VAR-based Granger causality was used to determine whether there is any form of causality between the variables and the direction of such causality. The result shows that producer price of maize does not granger cause cassava due to the fact the p-value is 0.4324 and exceeded 0.05 (Table 4) whereas producer price of cassava can Granger cause that of maize (p-value 0.0491which is almost equal to 0.05). Also, producer price of Rice does not granger cause cassava (p-value 0.5506 is more than 0.05) of which cassava producer price can granger cause Rice (p-value 0.0073 is less than 0.05) while rice and maize producer prices cannot granger cause each other. Therefore, it can be deduced that cassava producer price determines the producer prices of rice and maize which indicates a unidirectional causality meaning that a price change or market shock in cassava causes change in rice and maize while a change in both rice and maize does not necessary granger cause change in cassava production. But if otherwise it is bidirectional causality. Hence, the null hypothesis that the producer price does not granger cause each other is rejected.

## CONCLUSION

The result of Johansen co-integration test indicated that the selected crops during study period were well connected and had long run price linkage across them. Thus, the cassava, rice and maize producer prices were co-integrated and there

existed long run equilibrium. The result of VECM showed that maize producer price responded faster than cassava and rice. This implies that movement in Cassava and Rice prices was highly affected by price in Maize while movement in price of Maize was dictated by events in cassava and rice prices. The adjustment from the short-run to long –run equilibrium was about 277.92% which is relatively strong compared with the perfect adjustment of 100% threshold. It suggests that the prices of cassava, rice and maize adjust strongly to its long-run level after a price shock.

Granger Causality showed that cassava producer price influenced both rice and maize producers' prices in the market. Consequently, given the influence of producer price of cassava, good price policies to intensify cassava production should be enhanced.

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